Skillful wintertime, intraseasonal North American temperature forecasts based on the state of ENSO and the MJO

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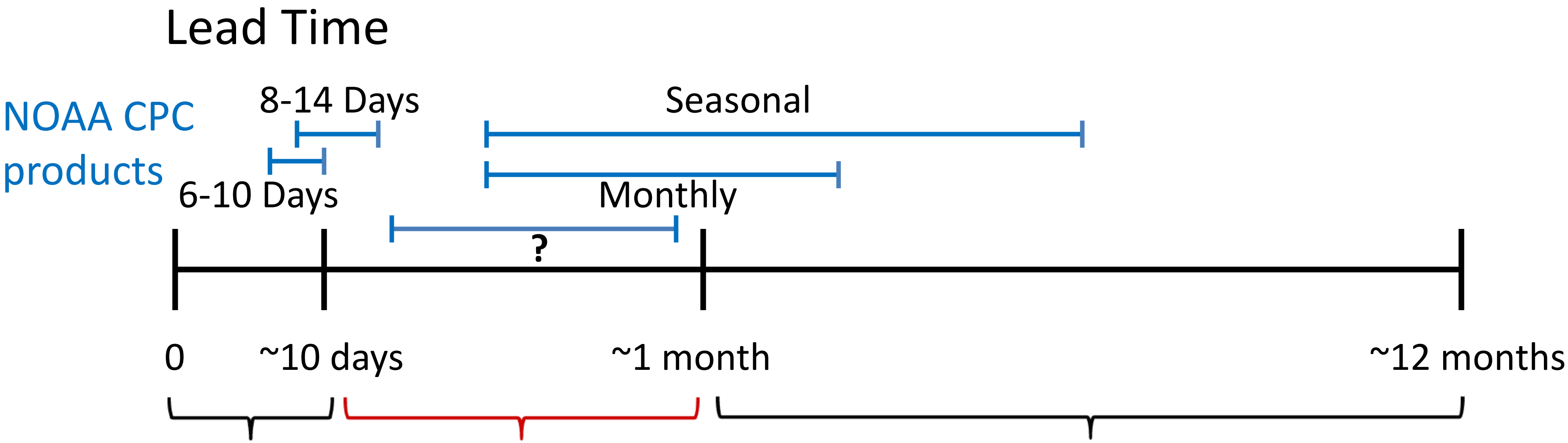
Can we bridge the forecast gap in weeks 3 and 4?



- Based on **initial conditions**
- Rely on numerical weather prediction (NWP) model integrations

Predictability gap:

- Large growth of initial errors
- Timescale too short for boundary conditions to take effect

- Based on slowly varying **boundary conditions**
- Rely on NWP model integrations and statistical forecast methods

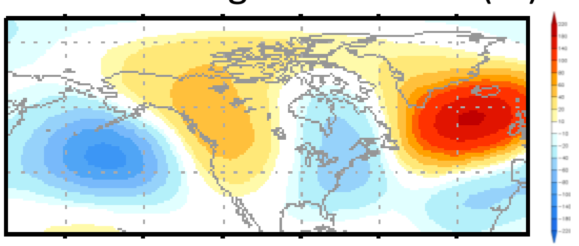
❖ **But Madden-Julian Oscillation (MJO) may help to fill the gap**

Our recent work demonstrates that the MJO strongly influences North American wintertime circulation for lead times of up to four weeks.

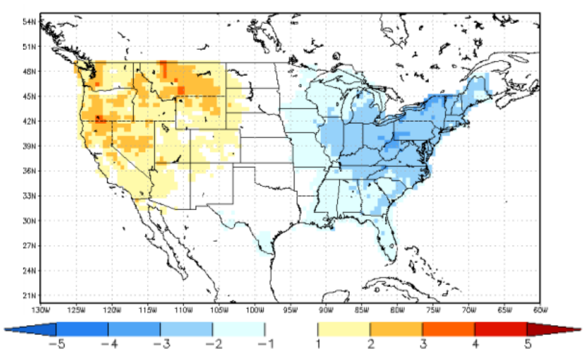
One of the dominant winter atmospheric patterns (top left) strongly affects U.S. temperatures (bottom left).

A weekly cluster pattern

500-hPa height anomalies (m)



Temperature anomalies (°C)

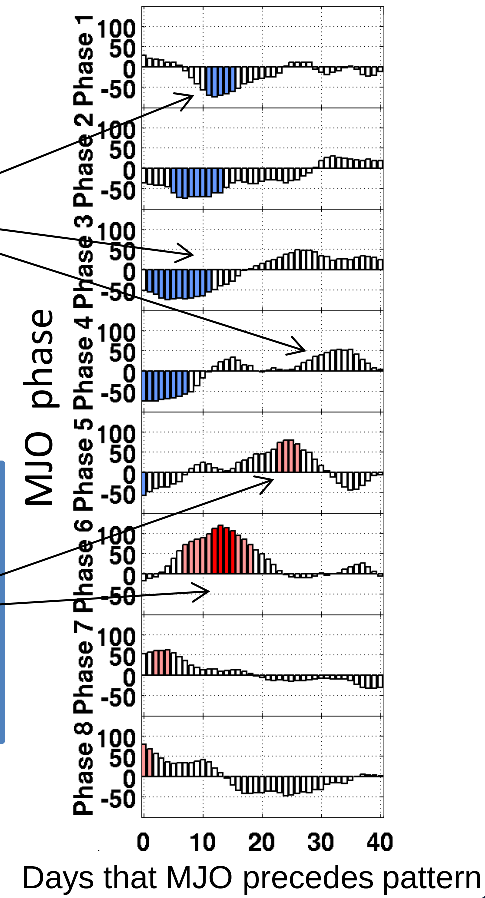


Riddle, Stoner, Johnson, L'Heureux, Collins, and Feldstein (2013, *Climate Dynamics*)

MJO influence on cluster pattern

Anomalous frequency of cluster pattern (top left) occurrence (%)

The MJO gives information on pattern occurrence 10-25 days in advance



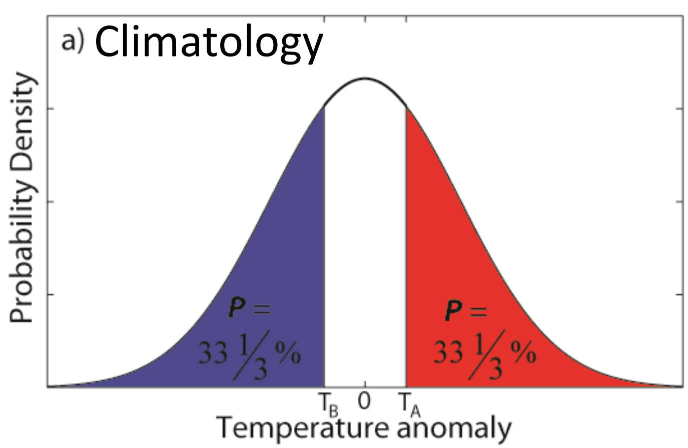
Generating probabilistic temperature forecasts based on the initial state of the MJO and ENSO

- ERA-Interim 2-m temperature (T2m) data, December – March 1980-2010, North America domain, 7-day running mean anomalies

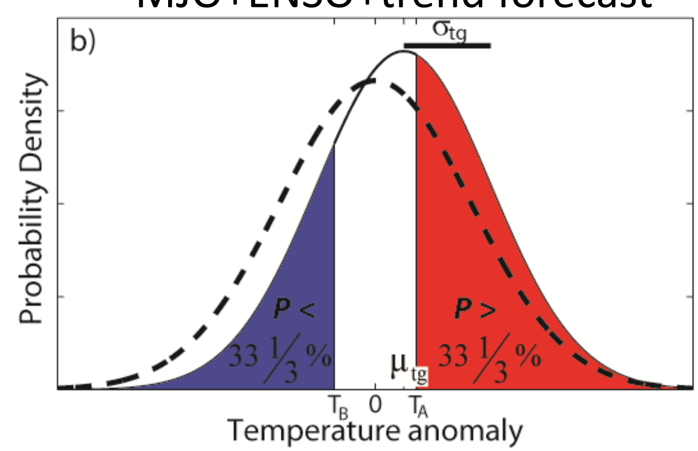
- forecasts for days 4-10 and weeks 2-6 with leave-one-year-out cross-validation

- Main forecast steps:
    1) Calculate mean and variance of T2m anomaly corresponding to MJO and ENSO state; add the two means and variances for each grid point and forecast lag

    2) With the assumption of a Gaussian T2m anomaly distribution and with a linear trend term added, calculate the probability of T2m in the upper and lower tercile for each lead time

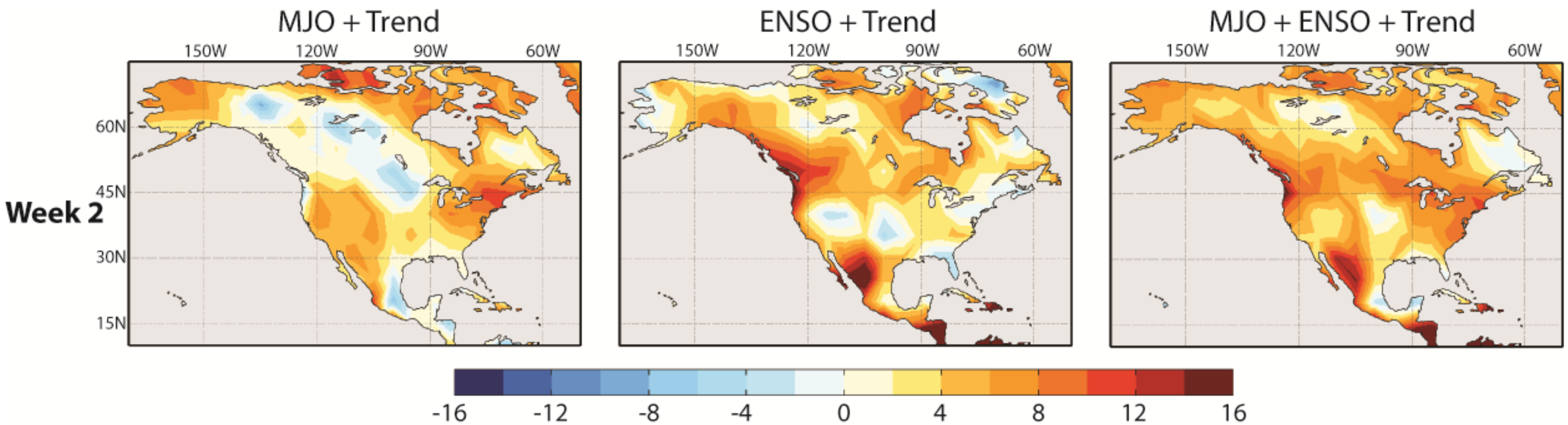


MJO+ENSO+trend forecast

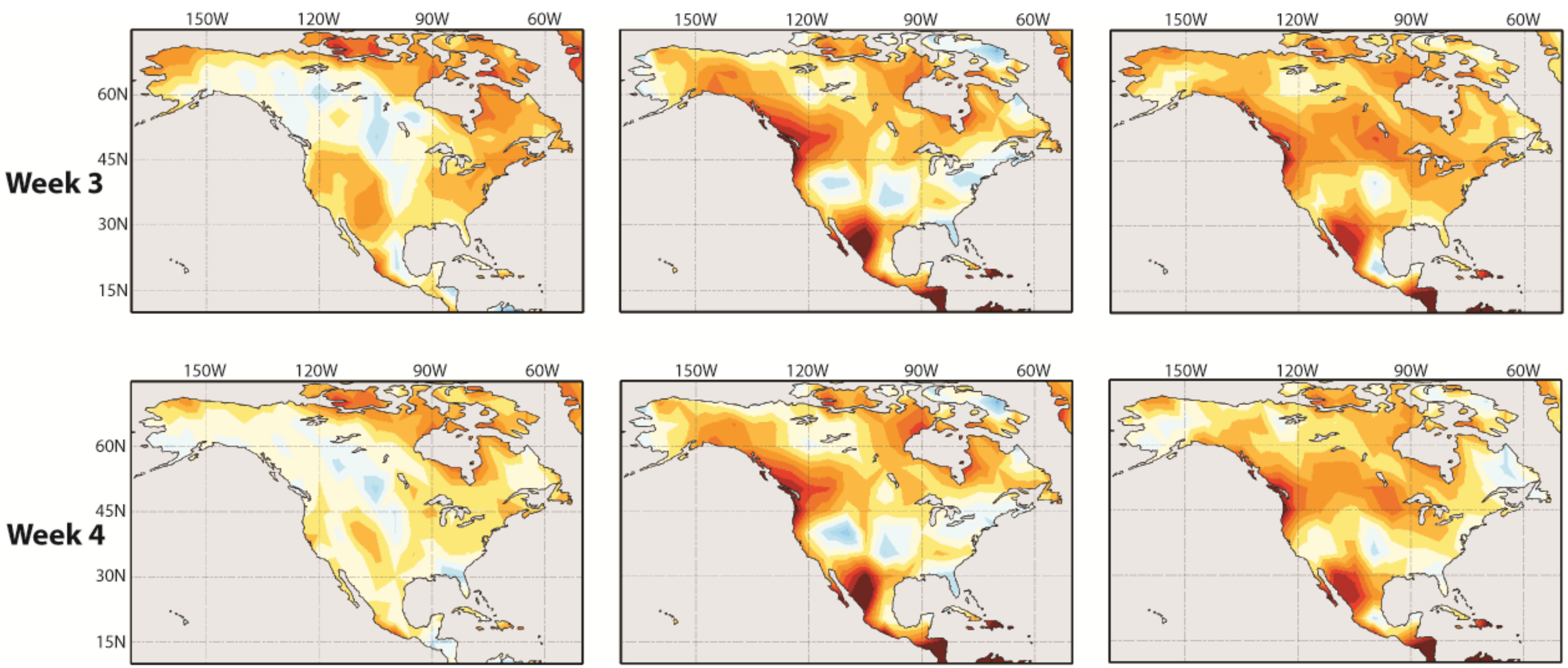


The MJO and ENSO primarily impact different regions of North America.

Mean Heidke Skill Scores (HSS)



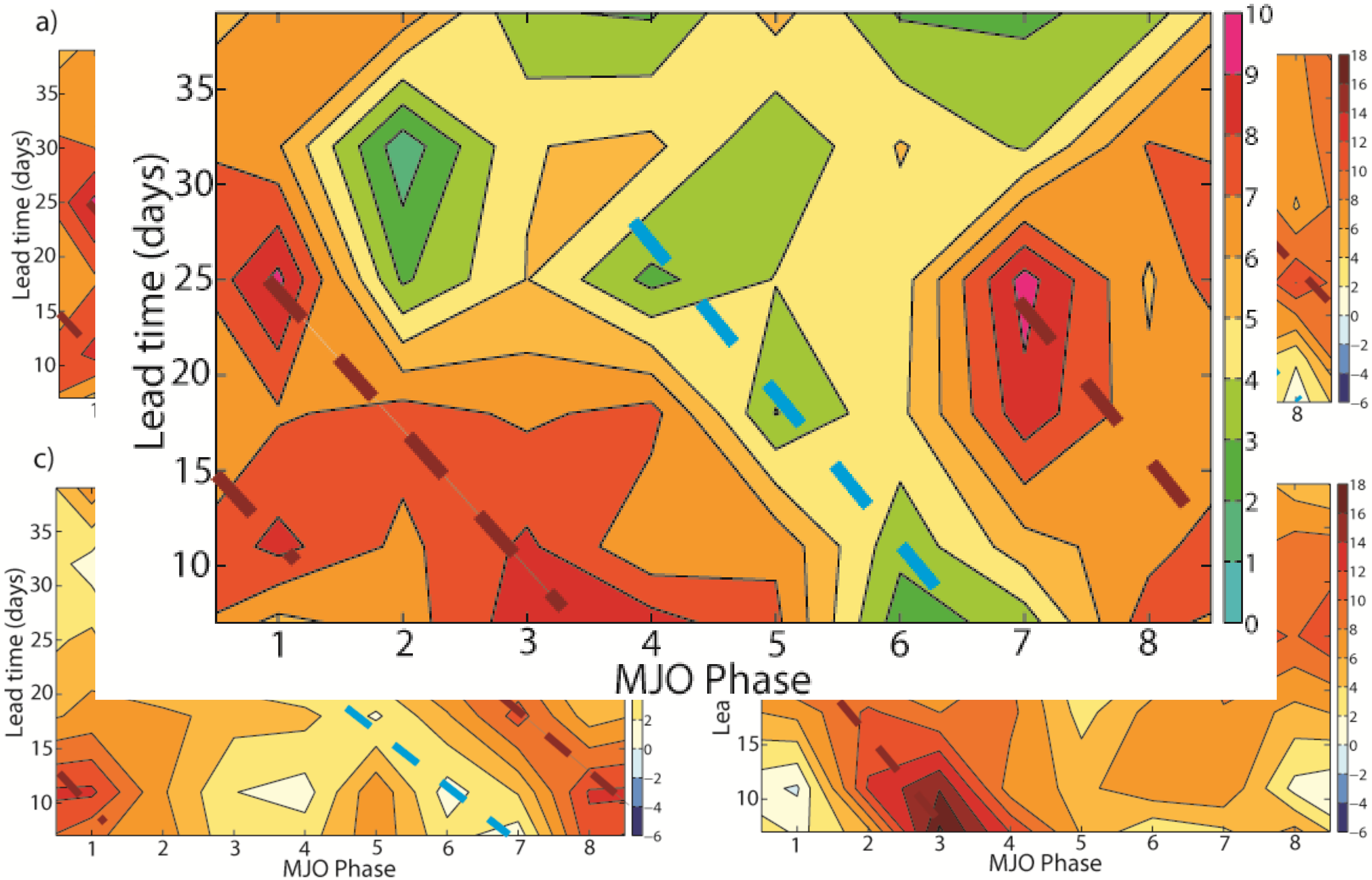
The MJO influence decays between weeks 2 and 4, whereas the ENSO influence remains nearly constant at these timescales.



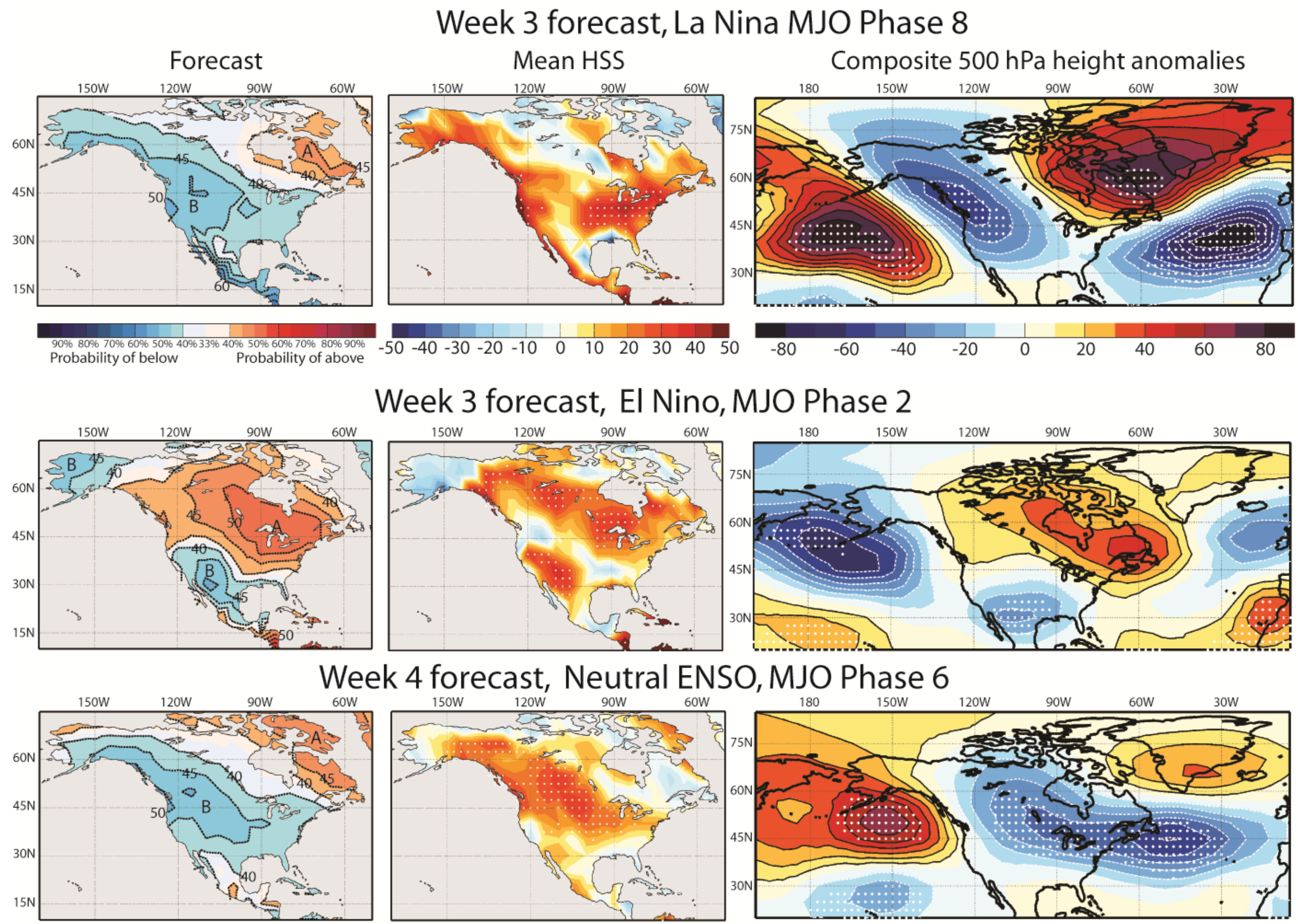
Particular MJO phases have stronger impacts on North American temperatures.

- Lin et al. (2010): oppositely signed tropical convective heating anomalies near 80°E and 160°E each produce an extratropical response over the North Pacific and downstream North America that reinforces each other
- Such an east-west dipole of convective heating corresponds with MJO phases 3 and 7

Spatial mean HSS

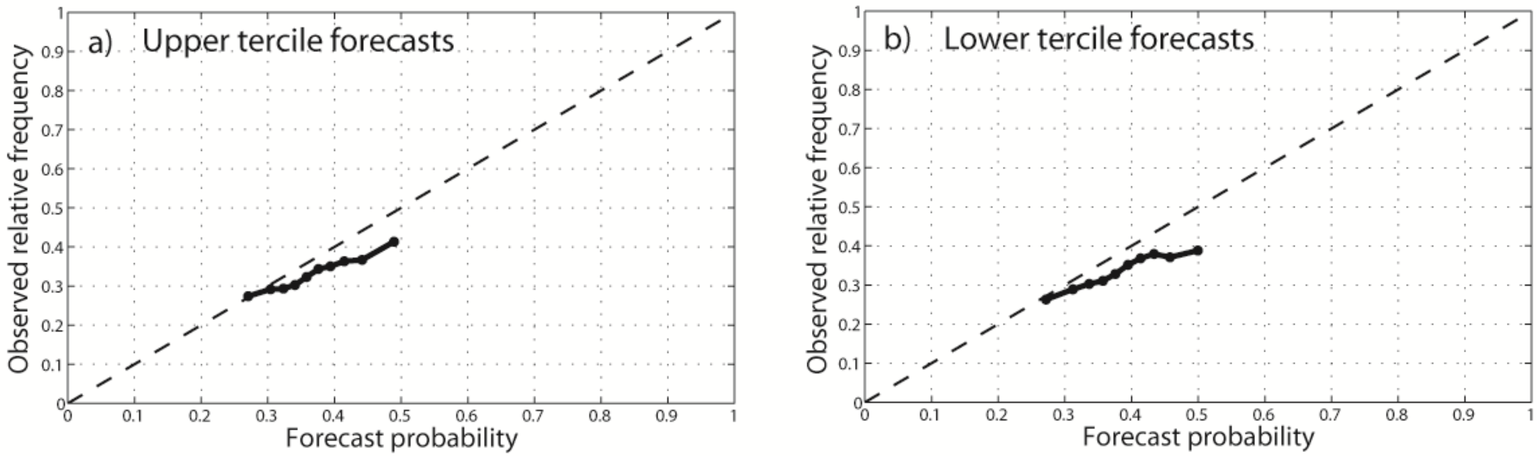


For some initial states of the MJO and ENSO, the skill scores of the weeks 3-4 T2m forecasts from the empirical model are substantially higher than the typical skill scores of NWP models.

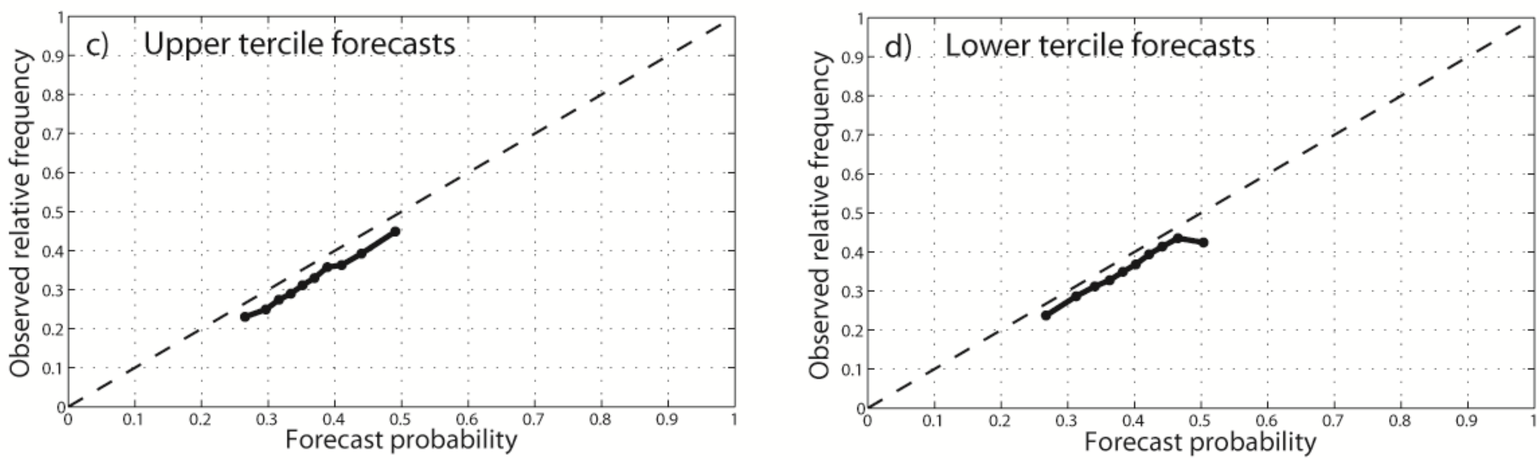


Calibration functions

All week 3 forecasts



Week 3 forecasts after MJO phases 1, 2 and 7



Conclusions

- A simple empirical model for probabilistic T2m forecasts based on the initial state of the MJO and ENSO and the linear trend produces skillful intraseasonal T2m forecasts over North America in winter.
- The primary ENSO regions of influence are distinct from those of the MJO.
- The skill scores from the empirical model in weeks 3 and 4 are much higher than the mean skill scores of the CFSv2 for some regions and for some initial states of the MJO.
- These elevated skill scores in weeks 3 and 4 occur for approximately 3-4 active MJO phases, which indicate such “forecasts of opportunity” may exist 25-30% of the time in winter.
- There is much room for refinement and extensions:
  - ➢ Extensions to other seasons, variables (e.g., precipitation), and regions
  - ➢ Extension to forecasts of extremes?
  - ➢ Refinement of the model (e.g., logistic regression?), add amplitude information
  - ➢ Investigation of other factors that influence the response in weeks 3 and 4 (e.g., stratospheric polar vortex, background flow)
  - ➢ Incorporation of dynamical forecast models like the CFSv2 into forecasts in weeks 3 and 4

Forecast of extreme T2m (upper and lower deciles)